REINFORCEMENT MAGNITUDE AND THE INHIBITING EFFECT OF REINFORCEMENT

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In a two-key concurrent variable-interval schedule (using pigeons), if the reinforcement frequency for one response is held constant while that for the other is increased, the rate of response on the constant key decreases. The immediate reinforcement for key pecking can usually be conceptualized as the change from a condition in which the key light is on and the food hopper light is off to one in which the key light is off and the hopper light is on. The prechange condition is associated with a delay to food of one-half the average interreinforcement interval in effect during this condition. The postchange condition is associated with a delay to food of about .5 seconds. The programming of additional reinforcement results in a decrease in the delay to food associated with the prechange stimulus condition, and thus a *decrease* in the value of the improvement that results from the change. This would appear to be analogous to a decrease in the amount of reinforcement, and thus sufficient explanation for the decrease in the rate of the response.

Key words: concurrent schedules, inhibiting effect of reinforcement, reinforcement magnitude, situation transition, stimulus change

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In a previous paper (Michael, 1975) it was argued that effective behavioral consequences should be conceptualized as stimulus *changes* rather than as static stimulus conditions. In spite of our common tendency to refer to the terminal components of such changes as "reinforcers" or "punishers," it is the change that actually constitutes the consequence, not the static endpoint of the change. For example, if a pigeon were exposed to a situation where variable-time schedules delivering 20, 40, and 60 rft/hr were associated with overhead lighting of red, yellow, and green hues, respectively, any low effort response which changed the overhead hue from red to yellow would almost certainly be maintained. Under such circumstances one might refer to the yellow overhead hue as a conditioned reinforcer, but this would be a mistake. The *change* from red to yellow certainly functions as conditioned reinforcement, but the yellow terminal con-

dition alone cannot be specified as a consequence. This point is easily appreciated by noting that a change from green to yellow would surely function as a form of conditioned punishment.

This stimulus-change interpretation of reinforcement and punishment was, in the earlier paper, a part of an argument against the usefulness of the distinction between positive and negative reinforcement. A very similar argument was made by Smith (1974, p. 127) in analyzing the relativity of reinforcement. Premack (1959, 1965, 1971) has also long argued against the view that a static stimulus condition can be assigned any absolute value as a form of reinforcement. Baum (1973) quite specifically defined reinforcement as a "transition from a lower-valued situation to a higher-valued situation" and later (1974) analyzed performance during the initial links of concurrent chain schedules in terms of a "situation-transition" concept of conditioned reinforcement.

More recently Fantino (1977) has presented a detailed analysis of conditioned reinforcement in terms of the delay reduction hypothesis (1969) which clearly implies a stimulus-change definition of reinforcement. (The analysis that follows, like Fantino's, involves conditioned reinforcement based on delay to

unconditioned reinforcement. The stimulus-change concept, however, is not limited to temporal factors; a change from one stimulus to another can function as reinforcement because the stimulus conditions are differentially associated with different quantities or qualities of unconditioned reinforcement, different amounts of effort involved in obtaining the unconditioned reinforcement, and other factors.) There are a number of other possible implications of an emphasis on reinforcement as stimulus change, and the purpose of the present paper is to suggest the relevance of this approach to the "inhibitory" effect seen in the performance of pigeons on concurrent variable-interval (VI) schedules.

In a two-key concurrent variable-interval schedule, if the reinforcement frequency for one response is held constant while that for the other is varied, the rate of responding on the constant key usually varies inversely with the reinforcement frequency provided for pecking the other key (Catania, 1963; Herrnstein, 1961). Furthermore, it is reasonably clear that this effect is not due primarily to the responding that occurs on the other key, but rather to the reinforcement that is provided for this responding. This has been shown by experiments in which the reinforcement on the other key has been signaled, thus producing a very low rate of responding on that key (Catania, 1963). The same general relation has been found when reinforcement amount (duration of hopper exposure) for pecking the other key is varied (Rachlin & Baum, 1969).

In a series of experiments using a single key, Rachlin and Baum (1972) found the same general inverse relation when the other reinforcement (varying either in frequency or amount) was scheduled on a variable basis on the same key (a) signaled by a key color change, (b) dependent upon the absence of key pecking for 2 sec, or (c) scheduled independently of key pecking. The title of the Rachlin and Baum paper is "Effects of alternative reinforcement: Does the source matter?" and they concluded that it does not. In the introduction to their paper they summarized the prior research as follows: "Reinforcement tends to increase the responding upon which it is dependent and decrease other responding. For any particular response, dependent reinforcement is excit-

atory and all other reinforcement is inhibitory" (p. 232).

Carrying this analysis one step further, Catania (1973) concluded that reinforcement has an inhibiting effect even on the response on which it is dependent. This "self-inhibiting" effect was described by Catania by reference to a hypothetical experiment, but one which was quite representative of actual data obtained by Catania and other investigators. The hypothetical experiment involves a pigeon in a two-key chamber in which food reinforcement is programmed according to variable-interval schedules. First, 30 rft/hr is programmed for pecking Key A and no reinforcers occur for pecking Key B. This results in 50 resp/min on Key A with little or no responding on Key B. Next, when 30 rft/hr is programmed concurrently on each key, the bird responds at a rate of 35 resp/min on each key. The added 30 rft/hr on Key B can be seen to have had two somewhat opposite effects: the total amount of behavior is increased from 50 to 70 (35 + 35) resp/min, but responding on Key A is decreased from 50 to 35 resp/min even though the rate of reinforcement on that key was not changed. Finally, instead of arranging the extra 30 rft/hr on Key B, they are added to the 30 that are already arranged for Key A, thus programming 60 per hour on Key A and none on Key B. This also results in a response rate of 70 resp/min, but all on Key A. Thus, the inhibiting effect that Key B reinforcement had on Key A responding was obviously not due to the bird's spending time pecking Key B since no more behavior is seen when the extra reinforcement is programmed on Key A itself.

Catania summarized: "We have already noted that reinforced responding decreases with increases in reinforcement from other sources. The present account argues that this effect holds for reinforcement from any source, including the reinforced response itself. According to this view, each reinforcer has an excitatory effect, specific to the response that produced it [and, in addition] an inhibitory effect that operates on all responses, including the one that produced it; it is in this sense that we shall claim that reinforcement is self-inhibiting" (1973, p. 518).

One can accept this general inhibitory effect as a basic principle of behavior, or at-

tempt to explain it in terms of already known relations. To this latter end, the concept of reinforcement as stimulus change, or situation transition, suggests at least a partial explanation. In Catania's hypothetical experiment, his real one reported in the same paper, and the other experiments mentioned earlier (Catania, 1963; Herrnstein, 1961; Rachlin & Baum, 1972), one can identify four clearly different stimulus situations: S_1, the home cage; S_2, the experimental chamber with the key lights on, the food-hopper light off, and the hopper inaccessible; S_3, the same chamber but with the key lights off, the hopper light on, and the hopper raised; and finally S_4, the stimulus condition that results from the ingestion of food. Each of these stimulus situations has a certain value, assuming an effective level of food deprivation. This value is at least roughly related (inversely) to the average delay to the ingestion of food. Thus, S_1, the home-cage stimulus condition, is related to an average delay to food of at least several hours. When 30 rft/hr is programmed on Key A with none on Key B, S_2 is associated with an average delay to food of about 60 sec (half of the VI 2-min average interreinforcement interval, since it is associated equally with the beginning, middle, and end of each interval). The key light off, hopper lit and up, (S_3) is associated with a delay of a fraction of a sec, and S_4 is the food ingestion itself.

The reinforcement for key pecking is the change from S_2 to S_3, or the change from a stimulus condition associated with an average delay to food of 60 sec to one associated with a delay of less than a sec. When 30 more rft/hr is programmed, whether on Key A or B, the S_2 stimulus condition is one that is associated with an average delay to food ingestion of only 30 sec (half of the VI 1-min average

interreinforcement interval).[1] Thus, S_2 is a stimulus condition that is now clearly of greater value. (This could probably be demonstrated by modifying the experiment so that some response is required for the transition from S_1 to S_2, that is, from the home cage to the experimental chamber. The probability of this response, measured as rate, or better, as resistance to some response-weakening operation [Nevin, 1974], would be found to be greater when S_2 was associated with a 30-sec average delay to food than when it was associated with a 60-sec average delay. Many chaining experiments confirm this general relation.) *But, if S_2 is of greater value, then the transition from S_2 to S_3 must now be a smaller magnitude of reinforcement than when S_2 was of less value.* Naturally, we would not expect this measure to be linear, but still it seems reasonable to assume that reducing the delay to food by 30 sec is less reinforcing than reducing it by 60 sec. The "inhibiting" effect of reinforcement, then, may be simply another instance of the relation between magnitude of reinforcement and strength of behavior. (A similar analysis can be made when the extra reinforcement is arranged by altering the hopper-exposure duration.)

To summarize, when food reinforcement is increased in frequency, regardless of the particular contingency, the stimulus change that functions as immediate reinforcement for the response being studied becomes a less valuable change. Under many circumstances this goes undetected because, although less valuable, the change is occurring more often, and the response strengthening effect of the increased frequency of reinforcement masks the effect of the decreased value of the stimulus change. In concurrent VI schedules such as those discussed above, the overall frequency of food reinforcement can be increased while the frequency relevant to a particular response

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[1]To the degree that the stimulus conditions in effect when the bird is pecking Key A are clearly discriminable from those associated with pecking Key B, it would be more appropriate to identify an S_{2A}, S_{2B}, S_{3A}, and S_{3B}. If, furthermore, the added reinforcements were highly specific in their effects on these stimuli, then the argument that follows would not hold. The issue is not whether the bird can discriminate which key it is pecking, or the different effects of pecking the different keys, however, but whether the value of S_{2A} with respect to the various delays to reinforcement blends with that of S_{2B}, and likewise for S_{3A} and S_{3B}. This blending is an

assumption underlying the principle line of reasoning of this paper. The fact that interactions between the components of multiple schedules are of a lesser magnitude than those between the components of concurrent schedules can be taken as a form of support for this assumption, as can the increased interaction when the components of the multiple schedule are reduced in duration. (See de Villiers, 1977, pp. 266ff, where multiple schedule interactions are reviewed in relation to the matching law.)

is held constant, in which case the decreased value of the reinforcing stimulus change leads to a decrease in response rate.

For those, like Herrnstein, who conceptualize the basic relation between reinforcement and response frequency as negatively accelerated, the interpretation suggested above simply constitutes one of the reasons for the negative acceleration. Other reasons are possibly related to a nonlinear increase in effort as response rate increases and, of course, ultimately to the physical limitations on responding. The strict interpretation of reinforcement as stimulus change also has obvious implications for understanding the contrast that is seen in multiple schedules (Reynolds, 1961).

The above description of the different stimulus situations and their relation to different delays to food is obviously oversimplified. As mentioned in Footnote 1, the stimulus situations could possibly be thought of as: S_{2A}, S_{2B}; S_{3A}, S_{3B}; and we should also add subscripts related to the passage of time, and to the condition of having just had food in the mouth; and these different conditions should actually be thought of as stimulus compounds undergoing constant change. These complications would certainly be expected to modify any simple relation such as described above, but not its general direction. On the other hand, they can be considered an argument against efforts at the present time to develop a relatively simple but comprehensive quantitative theory of the effects of reinforcement on behavior. Furthermore, if this general analysis is correct, to refer to any of these processes of effects as inhibiting would seem potentially confusing.

In any case, an analysis which emphasizes a stimulus-change definition of reinforcement may have the desirable effect of preventing the proliferation of behavioral principles which are themselves unexplained. Naturally there must be a small number of such basic relations which cannot be reduced to other behavioral relations, but the fewer the better. Finally, by placing the relation between magnitude of reinforcement and probability of responding in a critical explanatory role, this approach can be taken as support for molecular as opposed to molar orientations.

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